SPG Project Final Technical Report

1. Project details

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Report prepared by: Garry Hnatowich, ICDC Research Director
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4. Non-confidential abstract/ summary: *This must include project objectives, results, and conclusions for use in publications and on the SPG website. Maximum of 500 words in lay language. Please note that this summary will be used as such and no additional permission will be sought from the project applicant to publish the summary.*

A three year study was initiated in 2015 to investigate the effect of two rhizobia inoculant formulations, peat based on-seed and granular in-furrow, on yield and growth of faba bean across differing soil/climatic regions of Saskatchewan. Trials were established annually at Swift Current (brown soil zone) and Outlook (brown-dark brown transitional soil zone); Scott (dark brown soil zone) and Melfort, Yorkton, Indian Head and Redvers (black soil zone). Two faba bean varieties, a tannin and a zero tannin, were treated either with a peat based on-seed formulation (Nodulator brand by BASF) at the recommended rate of application (1.2 kg inoculant for 982 kg seed) or a granular in-furrow formulation (TagTeam brand by Monsanto BioAg) at 0.5X, 1.0X or 2.0X recommended application rates based upon row spacing used at each cooperating test site. Additional treatments included a dual inoculation combining the peat based inoculant applied at all three granular application rates. The peat based formulation was applied immediately prior to seeding using a damp inoculation method, granular products were applied at seeding.

Significant responses with respect to faba bean seed yield, at any individual test location over the three years of trialing, were few (2 of 15 site years). However, combined site analyses indicated an overall faba bean seed yield increase of approximately 230 kg/ha (3.5 bu/ac). This greatest yield response occurred with the peat based inoculant formulation by itself or in combination with a granular application, however the dual inoculation treatments were not statistically greater yielding in comparison to the peat based solo application. Inoculation had no statistically significant effect on seed protein, N content, total seed N uptake or seed test weight. Inoculation did not statistically influence vegetative biomass, tissue N content or total biomass N uptake but did result in an increase in plant height.

The overall minimal response cannot be attributed to soil providing adequate N for faba bean yield as the majority of sites were low in soil N according to spring soil testing procedures. Although mineralized N being released throughout the growing season is expected again the amounts of N removed in biomass and seed suggests that soil N sources would unlikely provide the quantities measured. Rather it is more likely that indigenous populations of *Rhizobium leguminosarum* were present at most trial locations and formed effective nodulation and subsequent biological nitrogen fixation to come close in optimizing faba bean growth and seed yield production. All sites involved in the trial have had an extended history of pulse crops within their rotations. While most pulses within their respective rotations have been field pea and/or lentil the *Rhizobium leguminosarum* inoculants applied are able to infect and provide nitrogen fixation in faba bean. Results from this trial suggest that inoculation of faba bean is still recommended but producers can choose an inoculant formulation based on cost and convenience for their operation. A single dose of inoculant is sufficient to provide optimal faba bean seed yield.

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5. Introduction: *Brief project background and rationale. (References are listed in the Appendix, Section 16)*

Interest in growing faba beans has increased among farmers, especially as a way to maintain pulses in the crop rotation without the disease issues of alternative pulse options, i.e. field pea or lentil. Although faba beans are not resistant to *Aphanomyces,* which currently infests many pea and lentil fields, they do have a higher tolerance to the level of infection from the disease as well as other root rot pathogens susceptible (Lamari and Bernier, 1985 and van Leur et al., 2008). Along with increased disease tolerance, faba beans are very efficient in fixing nitrogen (N) through *Rhizobium* symbiosis compared to other cultivated legumes and derives most of its' N required through atmospheric N fixation (Bremer et al., 1988). Farmers struggling to grow field peas or lentils because of disease issues could substitute faba beans in the rotation if faba beans perform well agronomically and economically.

Previous studies completed on faba bean agronomics focused on determining the best production practices for the

crop, i.e. seeding date, rates, depth, and row spacing are among the more popular topics (Jensen et al. 2010). Although some studies have focused on determining which species of *Rhizobium* bacteria colonize and infect the plant roots to form symbiotic relationships to carry out atmospheric N fixation (Slattery et al. 2004), there is no comprehensive study to determine the best commercially available inoculant option for faba bean. Current research suggests *Rhizobium leguminosarum bv. viciae* is the dominant species of *Rhizobium* that infect field peas, lentil and faba bean roots, forming nodules and which carry out N fixation (Evans et al. 1996). Unfortunately there is a lack of information regarding which strains of *Rhizobium leguminosarum bv. viciae* are in the new faba bean-specific inoculants. There are strains of indigenous faba bean –specific rhizobium in Western Canadian soils (Laguerre et al. 2003), however, these are not well defined in the literature.

Successful nodulation of the crop is extremely important to ensure the crop reaches maximum yield potential; therefore farmers need to inoculate their faba bean seed. The objective of this experiment is to develop recommendations for commercially available inoculants registered for faba beans, allowing farmers to select the best option and rate to maximize yield. Our experiment will test faba bean inoculants available to the market at varying rates and combinations. Determining which inoculant product and /or combinations will help producers achieve the greatest amount of economic return will hopefully give producers a more robust knowledge of faba bean production. As a result, encouraging them to be more comfortable when deciding to incorporate this new crop into their rotations.

6. Methodology: *Include approaches, experimental design, methodology, materials, sites, etc.*

Objective:

To determine the effects of two inoculants at different rates and in combination on Faba bean grown in various soil/climatic zones of Saskatchewan.

Agri-ARM Project Locations conducting trials 2015-17: Wheatland Conservation Area Inc. (WCA, Swift Current), Western Applied Research Corporation (WARC, Scott), Indian Head Research Foundation (IHARF, Indian Head), Northeast Agriculture Research Foundation (NARF, Melfort), East Central Research Foundation (ECRF, Yorkton), Southeast Agriculture Research Foundation (SERF, Redvers), Irrigation Crop Diversification Corporation (ICDC, Outlook)

Methodology 2015

The trial was established at all test locations as described below for 2016-17 however the tannin variety FB9-4 was used in the first year of the trial as opposed to the tannin variety CDC SSNS-1 used in years 2016 and 2017. The variety FB9-4 utilized across all locations in the trial initiation year resulted in serious seeding issues at the majority of site locations. The Thousand Kernel Weight (TKW) of 805 grams associated with the FB9-4's caused significant plugging at numerous sites. The plugging of seed occurred at the venturI, distributor, within hoses or in the opener depending upon the seeder being used to establish the trial. In an attempt to minimize plugging NARF seeded their FB9-4's plots twice – at a half rate per operation but still experienced difficulties. Consequently plant stand was compromised and less than desirable. The Snowdrop variety due to the randomized nature of the experimental design was also adversely affected as plugging may not have been detected until several plots had been seeded.

Due to plugging issues, plant counts were conducted after plant emergence and certain plots, at most sites, reduced to micro-plots. This may have been defined as reduction in plot length or width (e.g. plant counts & harvested area conducted on 6 m^2 compared to normal 12 m^2 area or normal 8 row plots reduced to 4-5 rows that did not plug). It cannot be disallowed that variation in plot sizes within a trial did not result in error of any agronomic parameters measured.

Consequently the decision was made to change the tannin faba bean variety to the smaller seeded CDC CCNS-1 for the remaining years of trialing.

Methodology 2016 & 2017

A consistent treatment protocol was observed and followed at all participating trial locations. Inoculants as indicated, their formulation and method of application was consistent across all sites. Two inoculants, Nodulator peat seed treatment (BASF) and TagTeam (Monsanto BioAg) a granular inoculant, were utilized in the study. Granular TagTeam inoculant treatments were metered through boxes or pre-weighed and applied through a cone on the seeder, granular inoculant was positioned within the seed row. The amount of granular inoculant (1x rate) was applied based on the manufactures recommended rate for the row spacings used at each trial location. Peat based Nodulator inoculant treatments were applied by damp inoculation method of applying 2.0 ml water to a kg of seed, adding 1.22 gm inoculant (recommended rate of 1.2 kg per 982 kg of seed), and mixing well in either a large plastic bag or plastic container. Seed-placed peat inoculant was applied to seed immediately prior to seeding. If seed treatments were utilized they were applied to the seed first and seed was fully dried prior to peat based inoculant application. Seed was treated with a registered seed treatment product for Faba bean at each location, excepting Indian Head. Supplemental fertilizer as 11-52-0 was applied at all locations at rates of 20 – 30 kg P_2O_5/ha and either side- banded or seed-placed depending upon location. Where required other supplemental nutrients were applied in quantities so as not be a yield limiting factor. Two faba bean varieties were evaluated in the trial to evaluate if they differed to inoculation treatments, varieties chosen were the zero tannin "Snowdrop" and the tannin variety "CDC SSNS-1." Target plant populations of both varieties was 43 – 58 plants m^{-2} (approximately 4 – 5 plants ft^{-2}), seeding rate was determined factoring seed size, germination and assuming 90% emergence for each variety. Faba bean varieties were centrally sourced by ICDC and the required quantities of each variety shipped to cooperating Agri-ARM facilities. At all sites plots were maintained weed free by herbicide burn-off prior to seeding, post herbicide applications and when required by hand weeding. Most sites received an in-season fungicide application for disease prevention. Harvest at all locations was accomplished with a small plot combine in a straight cut operation. At some locations Reglone was applied in a desiccation application, at other locations natural dry down occurred.

What did differ between locations was such practical aspects of date of seeding, method of seeding (direct vs worked), plot size, harvest date, etc., variables that would be expected to differ among a multi-organizational study such as this. Response data from all site-years were combined for mixed model analyses with the effects of site-year, variety, inoculant treatment and possible interactions were considered fixed and the effects of replicate (within site-year) considered random. All treatment means (both individual site-years and multi-site combined means) were separated by LSD testing analyses. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

Trial Design and Treatments:

This study was established in a randomized complete block design with four replications. Treatments were factorial in design with two faba bean varieties and eight inoculant rates and/or formulations, treatments are shown in Table 1. Agronomic and pertinent site establishment information is shown in Table 2.

Results of spring soil sampling are shown in Table 4. The Melfort trial site in 2016 was situated on ground that would be expected to interfere with inoculant performance. The remaining sites soil test N levels would not have been expected to mask or inhibit an inoculant response bases of spring soil test sampling.

All trial sites, other than Outlook, were reliant on annual in-season precipitation to maintain plant growth and development. The Outlook location has irrigation capacity however 2016 received only a single application of 12.5 mm due to the above normal precipitation throughout the growing season, in 2017 a total of 162.5 mm of supplemental irrigation was applied. In general, all sites received above normal precipitation throughout the 2016 growing season, in particular Swift Current. The Swift Current trial site received a total of 438 mm of rainfall from May 1 to September 30, greatly exceeding long-term norms. High precipitation consequently resulted in high yield potentials being established at the majority of test locations. The opposite rainfall situation occurred in 2017 with most sites experiencing drought, particularly Swift Current.

Table 1. Variety and Inoculant Treatments.

Treatments	Faba bean Variety	Inoculants
1	Snowdrop	Un-inoculated check
2	Snowdrop	Nodulator peat for Faba Beans
3	Snowdrop	0.5x rate TagTeam Granular for Faba bean
4	Snowdrop	1x rate TagTeam Granular for Faba bean
5	Snowdrop	2x rate TagTeam Granular for Faba bean
6	Snowdrop	Nodulator peat for Faba Beans + TagTeam granular for Faba Beans at 0.5x
7	Snowdrop	Nodulator peat for Faba Beans + TagTeam granular for Faba Beans at 1x
8	Snowdrop	Nodulator peat for Faba Beans + TagTeam granular for Faba Beans at 2x
9	CDC SSNS-1	Un-inoculated check
10	CDC SSNS-1	Nodulator peat for Faba Beans
11	CDC SSNS-1	0.5x rate TagTeam Granular for Faba bean
12	CDC SSNS-1	1x rate TagTeam Granular for Faba bean
13	CDC SSNS-1	2x rate TagTeam Granular for Faba bean
14	CDC SSNS-1	Nodulator peat for Faba Beans + TagTeam granular for Faba Beans at 0.5x
15	CDC SSNS-1	Nodulator peat for Faba Beans + TagTeam granular for Faba Beans at 1x
16	CDC SSNS-1	Nodulator peat for Faba Beans + TagTeam granular for Faba Beans at 2x

Table 2. General Site Agronomic Information of 2016 & 2017 Faba Bean Inoculant Trial.

Agronomic's	**Indian Head**	**Swift Current**	**Melfort**	**Yorkton**	**Outlook**	**Redvers**	**Scott**
Previous crop	Cereal	Cereal	Cereal	Cereal	Cereal	Cereal	Cereal
Tillage System	No-till	No-till	No-till	No-till	Tillage	No-till	No-till
Row spacing	30 cm	22.5 cm	30 cm	25 cm	25 cm	25 cm	25 cm

Table 3. Soil Test Information by Site, 2015 – 2017.

Soil Test Criteria	**Indian Head**	**Swift Current**	**Melfort**	**Yorkton**	**Outlook**	**Redvers**	**Scott**
	2015						
NO_3-N (0-60 cm)	12 kg ha^{-1}	39 kg ha^{-1} (0-30 cm)	62 kg ha^{-1}	24 kg ha^{-1} (0-30 cm)	53 kg ha^{-1}	39 kg ha^{-1} (0-45 cm)	40 kg ha^{-1}
PO_4-P (0-15 cm)	7 kg ha^{-1}	17 kg ha^{-1}	34 kg ha^{-1}	40 kg ha^{-1}	16 kg ha^{-1}	30 kg ha^{-1}	47 kg ha^{-1}
K (0-15 cm)	673 kg ha^{-1}	>415 kg ha^{-1}	>1000 kg ha^{-1}	>1000 kg ha^{-1}	649 kg ha^{-1}	595 kg ha^{-1}	569 kg ha^{-1}
SO_4-S (0-60 cm)	11 kg ha^{-1}	24 kg ha^{-1} (0-30 cm)	47 kg ha^{-1}	25 kg ha^{-1} (0-30 cm)	>179 kg ha^{-1}	41 kg ha^{-1}	57 kg ha^{-1}

OM % (0-15 cm)	5.2		12.4				
pH (0-15 cm)	8.0	6.8	5.8	7.4	8.0	7.6	
	2016						
NO_3-N (0-60 cm)	18 kg ha^{-1}	27 kg ha^{-1} (0-30 cm)	112 kg ha^{-1} (0-30 cm)	25 kg ha^{-1} (0-30 cm)	49 kg ha^{-1}	42 kg ha^{-1}	39 kg ha^{-1}
PO_4-P (0-15 cm)	8 kg ha^{-1}	13 kg ha^{-1}	22 kg ha^{-1}	25 kg ha^{-1}	18 kg ha^{-1}	27 kg ha^{-1}	62 kg ha^{-1}
K (0-15 cm)	>1200 kg ha^{-1}	>600 kg ha^{-1}	>600 kg ha^{-1}	>600 kg ha^{-1}	388 kg ha^{-1}	531 kg ha^{-1}	613 kg ha^{-1}
SO_4-S (0-60 cm)	20 kg ha^{-1}	>100 kg ha^{-1} (0-30 cm)	20 kg ha^{-1} (0-30 cm)	>70 kg ha^{-1} (0-30 cm)	>180 kg ha^{-1}	37 kg ha^{-1}	30 kg ha^{-1}
OM % (0-15 cm)	5.1		11.5		2.4		
pH (0-15 cm)	7.9	5.9	5.9	7.8	7.6	7.6	
	2017						
NO_3-N (0-60 cm)	16 kg ha^{-1}	38 kg ha^{-1} (0-30 cm)	63 kg ha^{-1} (0-30 cm)	27 kg ha^{-1}	72 kg ha^{-1}	24 kg ha^{-1} (0-45cm)	52 kg ha^{-1}
PO_4-P (0-15 cm)	11 kg ha^{-1}	20 kg ha^{-1}	18 kg ha^{-1}	18 kg ha^{-1}	16 kg ha^{-1}	8 kg ha^{-1}	71 kg ha^{-1}
K (0-15 cm)	>1200 kg ha^{-1}	>800 kg ha^{-1}	476 kg ha^{-1}	522 kg ha^{-1}	186 kg ha^{-1}	303 kg ha^{-1}	>800 kg ha^{-1}
SO_4-S (0-60 cm)	63 kg ha^{-1}	45 kg ha^{-1} (0-30 cm)	31 kg ha^{-1} (0-30 cm)	45 kg ha^{-1} (0-30 cm)	>140 kg ha^{-1}	>184 kg ha^{-1}	671 kg ha^{-1}
OM % (0-15 cm)	4.9	2.7	9.0	4.2	2.6	3.5	4.5
pH (0-15 cm)	7.6	6..0	6.1	7.2	8.2	7.7	6.0

7. Research accomplishments: *(Describe progress towards meeting objectives. Please use revised objectives if SPG approved revisions have been made to original objectives.)*

Objectives	**Progress**
1) To determine the effects of two inoculant formulations, peat on-seed and granular in-furrow, at different application rates and in combination on Faba bean grown across soil/climatic zones in Saskatchewan.	The study was conducted over a three year period. The overall effects of annual inoculation of faba bean grown in SK was modest, regardless of the area or region of production. The peat based formulation of inoculant was more effective than the granular inoculant.
2)	
3)	

8. Discussion: *Provide discussion necessary to the full understanding of the results. Where applicable, results should be*

discussed in the context of existing knowledge and relevant literature. Detail any major concerns or project setbacks.

Faba bean grain yield collected from each site with acceptable CV's (<15) for each treatment are outlined for 2015, 2016 and 2017 in Tables 3, 4 and 5 , respectively. In 2017, the final year of the trial the sites at Swift Current were adversely influenced by drought such that average treatment yields were only 381 kg/ha (5.7 bu/ac). The Scott location had high yields an unacceptable CV, the reason for the high yield variation is not apparent. The Melfort 2017 trial had seeding difficulties with the seeder used resulting in non-uniform stand establishment and excessive variation between and within treatments. Over the three years of the trial the majority of sites failed to achieve a positive yield response to inoculation. Combined summary of results is shown in Table 4. Overall, the tannin variety faba bean was higher yielding than the zero tannin but both responded, or failed to respond, to inoculation treatments in a similar fashion. Bare, un-inoculated faba bean produced the lowest yields. Yields were greatest whenever faba bean was treated with an on-seed peat based inoculant. The granular inoculation treatments, while numerically higher yielding, were not greatly higher than the un-inoculated. The relative failure of the granular inoculant to provide yields equal to a peat on-seed inoculant application is concerning and unexplainable. The granular and peat inoculants utilized with this study are produced by two different manufactures. It is highly probable that the strain of *Rhizobia leguminosarum* used within these products differs. Therefore it cannot be discounted that the strain used within the peat based formulation was superior to the strain within the granular formulation and accounts for the yield performance differences identified in Table 4. Additionally it should be noted that the net effect on enhancing faba bean yield with inoculation was modest. The maximum yield benefit obtained to inoculation across 15 site years of data was 236 kg/ha (3.5 bu/ac).

All trial sites used within this study have an extended history of pulse production, either with field pea and/or lentil. As *Rhizobia leguminosarum* bacteria are able to infect pea, lentil and faba bean and provide biological nitrogen fixation to occur it is possible that, with extended pulse inclusion within rotations, the background "indigenous" levels of *Rhizobia leguminosarum* in these soils is now high, resulting in diminishing yield responses to annual inoculation. In a recent Alberta study Lopetinski et. al. (2014) failed to obtain a faba bean yield response to inoculation in a six site-year study. In field pea McKenzie et. al., 2001 found an inoculant yield response in field pea at only 9 of 22 sites in Alberta. The average response to whenever peat based inoculant was applied (with or without granular applications) resulted in a 6.0% yield response which would provide an economic benefit. Although these results suggest that indigenous populations of *Rhizobia leguminosarum* may now be high through an extended history of pulse production in Saskatchewan, no commercial test is presently available to predict the likelihood of an inoculation response. Consequently this study suggests that producers continue to apply an inoculant to ensure the presence of adequate numbers of *Rhizobia leguminosarum* for faba bean production.

Table 5 shows the influence of variety and inoculation on seed protein, seed N percentage and seed N uptake, test weight, plant height, plant tissue N, plant biomass and total N uptake in biomass. The tannin variety faba bean contained higher seed N and therefore protein, higher seed N uptake and test weight compared to the zero tannin faba bean. Inoculation treatments had no influence on any of these factors excepting plant height, which increased with all inoculant treatments. All sites other than Melfort in 2016 had residual soil N levels that would not be expected to supply the N quantities measured in seed and biomass tissue. These overall lack of inoculation responses further suggests that faba beans within the confines of these test sites were being assisted by effective indigenous soil rhizobia thereby restricting, or limiting, positive fresh inoculation effects.

Table 3. Sites included in summary analyses.

Variety	Inoculant	2015 Site Yield (kg/ha)			
		Indian Head	Swift Current	Melfort	Yorkton
Snowdrop	Check	1045 f	712 g	2729 bcde	2109 a
Snowdrop	Nod peat	3286 c	1020 bcde	2637 cde	2082 a
Snowdrop	0.5X TT	1197 f	1031 bcde	2403 e	2149 a
Snowdrop	1.0X TT	1130 f	1110 bcde	2644 cde	2249 a
Snowdrop	2.0X TT	1493 e	1143 abc	2498 de	2097 a
Snowdrop	Nod + 0.5X TT	3085 c	1081 bcde	2552 de	2008 a
Snowdrop	Nod + 1.0X TT	3169 c	1122 bc	2634 cde	2118 a

Snowdrop	Nod + 2.0X TT	3140 c	1285 a	2986 abcde	2104 a
FB9-4	Check	1854 d	716 g	2912 abcde	2007 a
FB9-4	Nod peat	4946 a	1010 cde	3244 ab	2221 a
FB9-4	0.5X TT	1728 de	852 fg	3268 ab	2039 a
FB9-4	1.0X TT	1868 d	973 def	3417 a	2132 a
FB9-4	2.0X TT	1957 d	964 ef	3255 ab	2249 a
FB9-4	Nod + 0.5X TT	4623 ab	1105 bcde	3058 abcd	1790 a
FB9-4	Nod + 1.0X TT	4580 ab	1165 ab	3141 abc	2069 a
FB9-4	Nod + 2.0X TT	4359 b	1119 bcd	3076 abcd	2044 a
	Pr > F	0.0001	0.0001	0.001	0.918
	CV	7.1	10.1	14.2	14.7

Table 3. Continued

Variety	Inoculant	2016 Site Yield (kg/ha)						
		Indian Head	Swift Current	Melfort	Yorkton	Outlook	Redvers	Scott
Snowdrop	Check	3227 a	5728 bcdef	3816 a	4163 a	6581 a	5160 a	4998 a
Snowdrop	Nod peat	3503 a	6025 ab	3832 a	4350 a	6775 a	5321 a	4992 a
Snowdrop	0.5X TT	2987 a	5890 abcd	3951a	4326 a	6734 a	5026 a	5350 a
Snowdrop	1.0X TT	3222 a	5912 abcd	3754 a	4229 a	6727 a	5311 a	5299 a
Snowdrop	2.0X TT	3227 a	5964 abc	5358 a	3843 a	6627 a	5683 a	5360 a
Snowdrop	Nod + 0.5X TT	3220 a	5854 abcde	4202 a	4193 a	6777 a	5351 a	5340 a
Snowdrop	Nod + 1.0X TT	3371 a	6460 a	4114 a	3894 a	6482 a	4781 a	5325 a
Snowdrop	Nod + 2.0X TT	3353 a	6183 ab	3659 a	4223 a	6736 a	5441 a	5453 a
CDC SSNS-1	Check	3029 a	5143 f	3532 a	3408 a	7109 a	4389 a	5431 a
CDC SSNS-1	Nod peat	3205 a	5216 f	3688 a	4117 a	7053 a	4562 a	5203 a
CDC SSNS-1	0.5X TT	2982 a	5342 def	3503 a	4021 a	6887 a	4984 a	5259 a
CDC SSNS-1	1.0X TT	3019 a	5646 bcdef	3468 a	4063 a	7258 a	4950 a	5244 a
CDC SSNS-1	2.0X TT	3282 a	5395 cdef	3715 a	3706 a	7268 a	4821 a	5225 a
CDC SSNS-1	Nod + 0.5X TT	3251 a	5255 ef	3772 a	3833 a	7223 a	4456 a	5342 a
CDC SSNS-1	Nod + 1.0X TT	3216 a	5396 cdef	4107 a	4063 a	7313 a	4398 a	5152 a
CDC SSNS-1	Nod + 2.0X TT	3253 a	5351 def	3558 a	4296 a	7304 a	4767a	5210 a
	Pr > F	0.052	0.005	0.128	0.441	0.835	0.059	0.805
	CV	6.6	7.5	11.2	12.4	4.1	11.8	6.2

Table 3. Continued

Variety	Inoculant	2017 Site Yield (kg/ha)			
		Indian Head	Redvers	Outlook	Yorkton
Snowdrop	Check	1729 de	4543 a	3572 a	5203 a
Snowdrop	Nod peat	1777 de	4300 a	3634 a	5717 a
Snowdrop	0.5X TT	1702 e	3970 a	3799 a	5401 a

Snowdrop	1.0X TT	1780 cde	4249 a	3574 a	5891 a
Snowdrop	2.0X TT	1709 e	4082 a	3540 a	5927 a
Snowdrop	Nod + 0.5X TT	1699 e	4285 a	3419 a	5541 a
Snowdrop	Nod + 1.0X TT	1761 de	3859 a	3577 a	5438 a
Snowdrop	Nod + 2.0X TT	1693 e	4470 a	3539 a	5704 a
CDC SSNS-1	Check	2041 ab	3941 a	3841 a	5280 a
CDC SSNS-1	Nod peat	1981 ab	4223 a	3679 a	5766 a
CDC SSNS-1	0.5X TT	2098 a	3853 a	3591 a	5107 a
CDC SSNS-1	1.0X TT	2048 ab	3940 a	3777 a	5498 a
CDC SSNS-1	2.0X TT	2001 ab	4352 a	3405 a	5472 a
CDC SSNS-1	Nod + 0.5X TT	2077 a	4037 a	3698 a	5678 a
CDC SSNS-1	Nod + 1.0X TT	1901 bcd	4352 a	3623 a	5435 a
CDC SSNS-1	Nod + 2.0X TT	1951 abc	4532 a	3646 a	5541 a
	Pr > F	0.0001	0.139	0.970	0.601
	CV	6.5	9.1	10.6	9.1

Table 4. Combined Site Factorial Analyses for Faba Bean Grain Yield (kg/ha), 2015-17.

Treatment	15 Site Year Summary Yield (kg/ha)
Variety	
Zero Tannin	3782 b
Tannin	3931 a
Inoculation	
Check	3719 c
Nod peat	3952 a
0.5X TT	3758 bc
1.0X TT	3815 b
2.0X TT	3790 bc
Nod + 0.5X TT	3955 a
Nod + 1.0X TT	3925 a
Nod + 2.0X TT	3940 a
Pr > F (p-value)	
Variety (V)	0.0001
Inoculation (I)	0.0001
V x I	0.125

Table 5. Combined Site Analyses for Faba Bean Seed Quality and In-season Agronomic Observations, 2015-17.

Treatment	Seed Protein (%)	Seed N (%)	Seed N Uptake (kg/ha)	Seed Test Weight (kg/hl)	Height (cm)	Tissue N (%)	Plant Biomass (T/ha)	N Biomass Uptake (kg/ha)

Variety								
Zero Tannin	27.0 b	4.4 b	189 b	81.6 b	103 a	3.2 a	7.1 a	228 a
Tannin	28.1 a	4.6 a	205 a	82.3 a	103 a	3.2 a	7.1 a	228 a
Inoculation								
Check	27.6 a	4.5 a	197 a	82.1 a	100 b	3.2 a	6.9 a	222 a
Nod peat	27.5 a	4.5 a	199 a	82.0 a	103 a	3.2 a	7.4 a	241 a
0.5X TT	27.6 a	4.4 a	194 a	81.9 a	103 a	3.2 a	7.1 a	231 a
1.0X TT	27.7 a	4.5 a	199 a	81.8 a	103 a	3.2 a	7.2 a	234 a
2.0X TT	27.4 a	4.4 a	194 a	81.4 a	102 a	3.2 a	7.1 a	231 a
Nod + 0.5X TT	27.4 a	4.4 a	197 a	81.9 a	104 a	3.2 a	7.1 a	220 a
Nod + 1.0X TT	27.6 a	4.5 a	196 a	82.1 a	102 a	3.2 a	7.3 a	231 a
Nod + 2.0X TT	27.7 a	4.5 a	200 a	82.3 a	104 a	3.2 a	6.8 a	215 a
Pr > F (p-value)								
Sites	10	9	9	9	15	14	10	8
Variety (V)	0.01	0.01	0.01	>.01	0.97	0.87	0.86	0.98
Inoculation (I)	0.41	0.07	0.59	0.30	0.01	0.90	0.32	0.23
V x I	0.97	0.67	0.42	0.63	0.91	0.13	0.47	0.76

9. Conclusions and Recommendations: *Highlight significant conclusions based on the previous sections, with emphasis on the project objectives specified above. Provide recommendations for the application and adoption of the project.*

The overall minimal response of faba bean to inoculation was somewhat unexpected. In general inoculation provided a modest yield response that would cover the cost of a recommended rate of inoculant application. The peat based formulation was sufficient in providing optimal yields, equal or greater, than that of the granular inoculant. These results suggest that producers can make their faba bean inoculant formulation decision based on cost and convenience to their operation. Results of this trial suggest that it still be recommended that an inoculant be applied with faba beans as a small yield response is expected and for insurance as no valid method of predicting viable and sufficient background levels of indigenous rhizobia might be present to assist in faba bean growth and development.

10. Success stories/ practical implications for pulse producers or industry: *Identify new innovations and /or technologies developed through this project; and elaborate on how they might impact the producers /industry.*

11. Patents/ IP generated/ commercialized products: *List any products developed from this research.*

12. List technology transfer activities: *Include presentations to conferences, extension meetings or articles published in science journals or other magazines.*

This project was highlighted and toured at all the Agri-ARM sites at least once during the three year study duration. Numbers of producers and agronomists who viewed the study would easily exceed 1000 over the three year period. At Outlook alone in the trial initiation year it was highlighted during two separate field tours in recognition of 2016 being the "International Year of Pulses." Trials were signed to recognize the finacial funding provided by Saskatchewan Pulse Growers for the project. Results will also be made available in individual sites Annual Reports (many available on-line when completed) and as oportunities arise (oral presentations, popular agriculture press, fact sheets, etc.).

Acknowledgements:
The contributions of the professional staff and summer student assistance at all cooperating Agri-ARM sites is gratefully acknowledged and greatly appreciated.

13. List any other funding contributions or support received.

None

14. Future research potential arising from project. *Detail any further research, development and/or communication needs arising from this project.*

The minimal response of faba bean to annual inoculation leads to the question of whether field pea and lentil may also be subjected to reduced inoculation responses. If indigenous rhizobia populations have increased in Saskatchewan with repeated inclusion of these legumes in rotation, they may be providing effective biological fixation to be occurring. Should this be the case, formulations of inoculants based on price and/or convenience decisions might provide the necessary "insurance" for optimal yields at reduced savings to producers.

15. Acknowledgements. *Include actions taken to acknowledge support by the Saskatchewan Pulse Growers.*

Acknowledgement of the financial support provided by SPG has been recognized in annual reports and it is the intention of the Principal Investigator to develop a "Fact Sheet" of the results obtained from this study, full recognition to funding provided by the SPG will be made. Future presentations of results will continue to acknowledge the SPG.

16. Appendices: *Include any additional materials supporting the previous sections, e.g. detailed data tables, maps, graphs, photos, specifications, literature cited*

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